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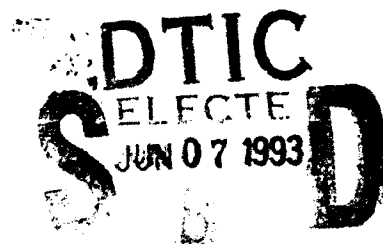


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REPORT NO. TN 93-5

AN ANNOTATED BIBLIOGRAPHY OF RESEARCH
INVOLVING WOMEN, CONDUCTED AT THE
US ARMY RESEARCH INSTITUTE OF
ENVIRONMENTAL MEDICINE

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts



93-12690



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UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

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1 AGENCY USE ONLY (Leave blank)		2 REPORT DATE	3 REPORT TYPE AND DATES COVERED Final	
4 TITLE AND SUBTITLE An annotated bibliography of research involving women, conducted at the US Army Research Institute of Environmental Medicine			5 FUNDING NUMBERS STO 3T/Task TM cc: 3410084TM3A00	
6 AUTHOR(S) James A. Vogel, Ph.D. and Anita K. Gauger				
7 PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Research Institute of Environmental Medicine Natick, MA 01760-5007			8 PERFORMING ORGANIZATION REPORT NUMBER	
9 SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) US Army Medical Research & Development Command Ft. Detrick, Frederick, MD 21702-5012			10 SPONSORING/MONITORING AGENCY REPORT NUMBER	
11 SUPPLEMENTARY NOTES				
12a DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b DISTRIBUTION CODE	
13 ABSTRACT <p>Recently considerable attention has been given to the lack of biomedical research on women's health problems. Within the military services, this concern for lack of research with women or lack of inclusion of women subjects in research has been extended to most areas of human performance investigation. As women move into an increasing number of military occupations, it is apparent most military research on health and performance has been conducted on male research volunteers. The many anthropometric, body compositional, physiological and endocrinological differences between genders make it obvious that much of the male research data can not be readily extrapolated to females. Although this issue has only recently received broad attention, the US Army Research Institute of Environmental Medicine (USARIEM) has already executed many studies which either addresses women-related issues or include women in the study population. This report is a bibliography of these studies, complete with abstracts, intended to serve as a convenient resource for women-related health and performance research information. It is anticipated that these references will prompt additional biomedical research related to women in the military.</p>				
14 SUBJECT TERMS Women; Gender Differences; Health Research; Military Performance; Anthropometry; Physiology; Body Composition; Endocrinology.			15 NUMBER OF PAGES	
			16 PRICE CODE	
17 SECURITY CLASSIFICATION OF REPORT Unclassified	18 SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19 SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20 LIMITATION OF ABSTRACT	

Technical Note No. 93-5

**AN ANNOTATED BIBLIOGRAPHY OF RESEARCH INVOLVING
WOMEN, CONDUCTED AT THE US ARMY RESEARCH INSTITUTE OF
ENVIRONMENTAL MEDICINE**

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May 1993

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INTRODUCTION

Recently considerable attention has been given to the lack of biomedical research on women's health problems. Within the military services, this concern for lack of research with women or lack of inclusion of women subjects in research has been extended to most areas of human performance investigation. As women move into an increasing number of military occupations, it is apparent most military research on health and performance has been conducted on male research volunteers. The many anthropometric, body compositional, physiological and endocrinological differences between the genders make it obvious that much of the male research data can not be readily extrapolated to females. Although this issue has only recently received broad attention, the US Army Research Institute of Environmental Medicine (USARIEM) has already executed many studies which either addresses women-related issues or include women in the study population. This report is a bibliography of these studies, complete with abstracts, intended to serve as a convenient resource for women-related health and performance research information. It is anticipated that these references will prompt additional biomedical research related to women in the military.

Articles, Chapters, Proceedings

1. Tomasi, L.F., Peterson, J.A., Pettit, G.P., Vogel, J.A. and Kowal, D.M. Women's response to Army training. The Physician and Sportsmedicine, 5:32-37, 1977.

In order to prepare for the law requiring the military academies to open admissions to women beginning in 1976, a study was conducted by the Exercise Physiology Division, USARIEM, and the Physical Education Office, US Military Academy, to determine the necessary adjustments in testing and training to make this change. The project was called "Project 60", referring to the 60 high school (16-18 year old) volunteers that were recruited from high schools in the West Point area. After extensive physical fitness baseline testing, the group was divided into three subgroups: control with no physical training, strength training three days per week, and "reveille exercise" training four days per week. Reveille consisted of calisthenics, rifle drill and running that was employed for new plebes during the initial seven-week training at the Academy. Injuries during the seven-week experimental training period were carefully recorded and reported in this report. Physiological responses to the various training programs were evaluated and contrasted during post training repeated tests of fitness. These women were particularly susceptible to lower limb orthopaedic problems. Particular care must be taken to implement progressive exposure to exercise stress.

2. Kowal, D.M., Patton, J.F. and Vogel, J.A. Psychological states and aerobic fitness of male and female recruits before and after basic training. Aviation, Space, and Environmental Medicine, 49:603-606, 1978.

Psychological states and aerobic fitness were measured using a battery of psychological tests and a bicycle-ergometer work test. A group of approximately two hundred male and female subjects were tested at the beginning of a six-week basic training cycle and another group of two hundred

were tested at the completion of basic training. A difference in mood, anxiety, self confidence and physical fitness was evident in the groups of male recruits, but not in the female recruits after training. A significant difference existed between males and females in terms of physical work capacity.

3. Burse, R.L. Sex differences in human thermoregulatory response to heat and cold stress. Human Factors, 21:687-699, 1979.

The current literature on male-female differences in response to thermal stress is reviewed. Morphologically, women average 20% smaller body mass, 14% more body fat, 33% less lean body mass, but only 18% less surface area than men. Women have greater body insulation when vasoconstricted (except hands and feet) and a larger peripheral heat sink, but at the cost of (1) greater body fat burden, (2) less muscle mass and strength, and (3) smaller circulating blood volumes which require greater physiological strain to balance heat production and loss. Under heat stress, women generally show (1) relatively more peripheral blood pooling, (2) greater heart rate increases, (3) more frequent circulatory embarrassment, (4) lower maximal sweat rates, (5) higher skin temperatures with greater body heat storage, and (6) poorer maintenance of circulating blood volume with more impact from dehydration. Proportionately, fewer women than men can be successfully heat acclimated. In the cold, women generally have (1) less capability for maximum heat production by either exercise or shivering, (2) a more extensively vasoconstricted periphery, (3) lower foot, hand, and mean skin temperatures, (4) greater surface heat losses, especially from the geometrically thinner extremities, (5) increased rates of extremity (but not core) cooling, and (6) relatively greater risk of cold injury.

4. Daniels, W.L., Kowal, D.M., Vogel, J.A. and Stauffer, R.M. Physiological effects of a military training program on male and female cadets. Aviation, Space, and Environmental Medicine, 50:562-566, 1979.

Twenty-nine males and 26 females (17-21 years old) were tested at the

beginning and at the end of the six-week training program which all incoming cadets (plebes) undergo upon entering the U.S. Military Academy. The aerobic training consisted of running for 30 min 5-6 d/week at varied speeds, depending upon performance in an initial 1.5 mile run test. Females responded to training with a significant increase ($p < 0.0001$) in $\dot{V}O_2$ max from 46.0 ± 1.0 to 49.7 ± 0.8 ml/kg \cdot min (7.9%). Males did not increase their initial $\dot{v}O_2$ max (59.4 ± 1.1 ml/kg \cdot min) significantly. Both groups significantly reduced HR_{max} and percent body fat. Their initial $\dot{V}O_2$ max values and activity history accounted for the lack of a significant increase in this highly-fit population of males. Blood lactates were significantly decreased ($p < 0.05$) at the same two submaximal workloads after training. The initial difference in aerobic power between males and females was reduced from 22% to 18%.

5. Avellini, B.A., Shapiro Y., Pandolf, K.B., Pimental, N.A. and Goldman, R.F. Physiological responses of men and women to prolonged dry heat exposure. Aviation, Space, and Environmental Medicine, 51:1081-1085, 1980.

Heat-acclimated men ($n=10$) and women ($n=9$) were exposed to hot-dry conditions (49°C , 20% rh) for four hours to determine the effect of prolonged work in the heat on physiological differences between the sexes. Hourly exposures consisted of ten min resting and 50 min walking at $1.34 \text{ m} \cdot \text{s}^{-1}$ (time-weighted metabolic rate = 175 and 151 $\text{W} \cdot \text{m}^{-2}$ for men and women, respectively). No significant difference in rectal temperature (T_{re}) was found between the sexes for each hour (h) of exposure. Heart rate (HR) of women, however, averaged 10-17 beats per min $^{-1}$ higher than men. Mean skin temperature (T_{sk}) was also significantly higher in women throughout the exposure. For both sexes, the 4th-h T_{re} , HR, and T_{sk} were significantly higher than the preceding 3 h. No sex related differences in total sweat rate (m_{sw}) or sweat sensitivity, as indicated by $m_{sw}/\Delta T_{re}$, were evident. It was concluded that: a) prolonged exposure to dry heat does not accentuate physiological differences between the sexes; b) women sweat at rates comparable to men over a four-hour period; c) 2-h acclimation sessions do not necessarily acclimate individuals for work of longer duration.

6. Evans, W.J., Winsmann, F.R., Pandolf, K.B. and Goldman, R.F. Self-paced hard work comparing men and women. Ergonomics, 23:613-621, 1980.

Six fit male subjects (23 years, 171 cm, 67 kg, maximal $\dot{V}O_2 = 2.25 \text{ mmol kg}^{-1} \text{ min}^{-1}$ ($50 \cdot 3 \text{ ml kg}^{-1}$)) and six fit female subjects (22 years, 163 cm, 57 kg, maximal $\dot{V}O_2 = 1.83 \text{ mmol kg}^{-1} \text{ min}^{-1}$ ($41.1 \text{ ml kg}^{-1} \text{ min}^{-1}$)) performed self-paced hard work while walking over four different terrains carrying no external load, 10 kg and 20 kg. Time on each course for individual subjects was used to determine speed and energy expenditure; heart rate was recorded as each subject completed each course. Walking speed and energy expenditure of the males were found to be significantly greater ($p < 0.05$) than those of the females over all terrains (blacktop road, 1.6 km; dirt road, 1.8 km; light brush, 1.4 km; and heavy brush, 1.3 km) and for each load carriage condition. Relative energy expenditures of the males and females for all conditions were very similar ($p > 0.05$) and remarkably constant at a value close to 45% $\dot{V}O_2 \text{ max}$. These data indicate that the voluntary hard work rate is dependent upon maximal aerobic power. The best predictor of speed for self-paced hard work of males and females for one to two hours in duration appears to be based on 45% of maximal aerobic power.

7. Knapik, J.J., Wright, J.E., Kowal, D.M. and Vogel, J.A. The influence of U.S. Army basic initial entry training on the muscular strength of men and women. Aviation, Space, and Environmental Medicine, 51:1086-1090, 1980.

The influence of U.S. Army basic initial entry training on the maximum voluntary isometric strength (MVIS) and anthropometric parameters of men and women was investigated. Significant increases in weight and lean body mass (LBM) and decreases in percent body fat were found for both sexes during training. Significant increases in the MVIS of the upper torso (UT), leg extensors (LE), and trunk extensors (TE) were found for both sexes. Females and males improved about the same amount on the LE (12.4% and 9.7%, respectively), but females improved significantly more than males on the UT (9.3% and 4.2%, respectively) and TE (15.9% and 8.1%, respectively). The

greater gains in the females were presumably due to their lower initial strength levels and the consequently greater relative training stimulus. When strength was expressed relative to lean body mass (LBM), both sexes were able to exert similar amounts of strength on the LE and TE, suggesting that differences in strength between the sexes may primarily be a function of muscle mass.

8. Kowal, D.M. Nature and causes of injuries in women resulting from an endurance training program. American Journal of Sports Medicine, 8:265-269, 1980.

A prospective study was initiated to identify exercise-related injuries and performance-limiting conditions that resulted from an eight-week physical training program and to identify some of the factors that may contribute to their occurrence. Four hundred women recruits (age 18 to 29 years) participated in the study. Fifty-four percent (215) of the women sustained some reportable injury. These injuries resulted in an average training time loss of 13 days. Forty-one percent of these injuries prevented participation in all activity; 31% resulted in only limited participation. Early training "overuse syndrome" accounted for 42% (92) of the reported injuries. The results indicated that a major cause of injury in women can be attributed to the lack of prior conditioning, greater body weight and fat percent, and limited leg strength. These factors, coupled with some inherent physiologic characteristics of women (i.e., wide pelvis, less strength, and greater joint flexibility), probably contributed to the increased risk of injury in these women.

9. Patton, J.F., Daniels, W.L. and Vogel, J.A. Aerobic power and body fat of men and women during Army basic training. Aviation, Space, and Environmental Medicine, 51:492-496, 1980.

Maximal oxygen uptake ($\dot{V}O_2$ max) and percent body fat (%BF) were assessed in 87 males and 57 females before and after seven weeks of Army basic training. $\dot{V}O_2$ max was determined using a running treadmill protocol and

assessed in 87 males and 57 females before and after seven weeks of Army basic training. $\dot{V}O_2$ max was determined using a running treadmill protocol and %BF was measured by skinfold technique. $\dot{V}O_2$ max increased 3.7% (50.7 vs 52.3 ml/kg.min) and 10.5% (36.9 vs 39.3 ml/kg.min) for males and females, respectively, with training. %BF decreased 11% in males and 7.1% in females while body weight increased in both. Analysis of variance revealed that, while these changes were significant, there was no quantitative difference in the response of the sexes undergoing the same training program. The data suggest that basic training presents an effective physical challenge for those males and females who have a $\dot{V}O_2$ max below the ranges 49-52 ml/kg·min, and 38-41 ml/kg · min, respectively, upon entry. In addition, it effectively reduces BF content of those who initially possess high percentages and increases the lean body mass particularly in women.

10. Shapiro, Y., Pandolf, K.B. and Goldman, R.F. Sex differences in acciimation to a hot-dry environment. Ergonomics, 23:635-642, 1980.

Sex-related differences in acclimation to a hot-dry environment were evaluated in ten males and nine females. The subjects were exposed during early spring to a hot-dry climate: 49°C, 20% rh for six consecutive days. Exposures lasted 120 min: 10 min rest, 50 min walk (1.34 m s⁻¹), 10 min rest, 50 min walk. Heart rate, rectal temperature (T_{re}), mean skin temperature (T_{sk}), and heat storage dropped significantly for both sexes ($p < 0.05$) from the first to the sixth day, with no significant changes ($p > 0.05$) between the last two days. In spite of similar metabolic rates, similar sweat rate and lower heat gain by radiation and convection for the females, their T_{re} and T_{sk} remained significantly higher ($p < 0.05$) than those for the males at the end of acclimation. It was suggested that the thermoregulatory set point is higher for unacclimated women than for men, and that this difference does not disappear with acclimation.

11. Shapiro, Y., Pandolf, K.B., Avellini, B.A., Pimental, N.A. and Goldman, R.F. Physiological responses of men and women to humid and dry heat. Journal of Applied Physiology: Respiratory, Environmental and Exercise Physiology, 49:1-8, 1980.

Sex-related differences were evaluated in ten males and nine females under hot-wet and hot-dry conditions. Preacclimatized subjects were exposed to a comfortable climate (20°C, 40% rh), mild-wet weather (32°C, 80% rh), two hot-wet conditions (35°C, 90% rh; 37°C, 80% rh), and two hot-dry conditions (49°C, 20% rh; 54°C, 10% rh). Exposures lasted 120 min: 10 min rest, 50 min walk (1.34 m·s⁻¹), 10 min rest, 50 min walk. During hot-dry exposures, heart rate (HR) and rectal temperature (T_{re}) were significantly lower for males than females by 13 and 20 beats · min⁻¹ and by 0.25 and 0.32°C for the two conditions; no significant differences in sweat loss (m_{sw}) were observed. During hot-wet exposures, both mean final T_{re} and m_{sw} were lower in females than males by 0.34 and 0.24°C and by 106 and 159 g · m⁻² · h⁻¹, respectively (males sweated 25 and 40% more than females). None of these differences correlated with maximal O₂ uptake, body weight, skin surface area, or percentage of body fat. During hot-wet exposures, a negative relationship between surface area-to-mass ratio (An/wt) and T_{re} , mean skin temperature, HR, and change in heat storage was found. It was suggested that three major factors are involved in these differences: 1) higher An/wt for females than for males, 2) better sweat suppression from skin wettedness for women, and 3) higher thermoregulatory set point for women than men.

12. Vogel, J.A., Wright, J.E. and Patton, J.F. Development of new gender-free physical fitness standards for the Army. In: Proceedings of the Army Science Conference, U.S. Military Academy, West Point, NY, June 1980.

This report outlines a process that was developed to establish gender-free occupationally-related physical fitness standards which could be used for military occupation selection and assignment. The process is based on the following assumptions: a) standards should be established for two separate

components of physical fitness - aerobic and muscle strength fitness, b) standards should be based on objectively determined physical demands of occupations, c) standards should be established for groups or clusters of occupations who apparently have similar fitness requirements, d) standards should be based on the most demanding tasks found within each occupational grouping, and e) the precision of the scale of standards should be commensurate with operational needs. Steps are outlined in proceeding from the physical task lists of occupations, to the resulting standards for groups of occupations. Standards were established for two categories of fitness, at three levels of intensity, and for a total of five clusters of occupations.

13. Bauman, C.L., Knapik, J.J., Jones, B.H., Harris, J.M. and Vaughan, L.K. An Approach to Musculoskeletal Profiling of Women in Sports. In: Sports Medicine, Sports Science: Bridging the Gap. I.R. Cantu and W. Gillespie (Eds.), Health Publications, Lexington, MA, 61-72, 1982.

This chapter reviews the incidence of injuries related to sports participation in women athletes. It suggests an approach to profiling (assessing) various physical and physiological characteristics of women athletes in order to identify predisposing factors for athletic injuries. The profiling system includes the following major areas: medical history, muscle strength, orthopedic alignment, joint laxity, and flexibility.

14. Daniels, W.L., Wright, J.E., Sharp, D.S., Kowal, D.M., Mello, R.P. and Stauffer, R.S. The effect of two years' training on aerobic power and muscle strength in male and female cadets. Aviation, Space, and Environmental Medicine, 53:117-121, 1982.

During their first two years of training at the U.S. Military Academy, 11 male and 7 female cadets were studied on five occasions. $\dot{V}O_2$ max (l/min), lean body mass and body weight increased significantly in both groups. Percent body fat was significantly reduced only after the first summer of training

and then returned to initial values. $\dot{V}O_{2\max}$ (ml/kg·min) did not change in males during the study. However, females increased significantly after the initial six weeks of training (44.2 to 48.8 ml/kg·min). They remained at this level through the second summer of training. However, by the end of their second academic year, females' values dropped to 45.9 ml/kg·min. Maximal isometric strength measured 30-40% higher in males than in females. During the last year of training, arm and shoulder strength increased 10.2% in males, but was unchanged in females. Our results suggest that even extended military training did not enable females to significantly narrow the difference with male cadets in muscle strength and aerobic power.

15. Horstman, D.H. and Christensen, E. Acclimatization to dry heat: active men vs. active women. Journal of Applied Physiology, 52:825-831, 1982.

Physiological responses to exercise in dry heat were compared between six active men [maximum O_2 consumption ($\dot{V}O_{2\max}$), 51.4 ± 1.2 ml·kg⁻¹ · min⁻¹] and four active women ($\dot{V}O_{2\max}$), 47.2 ± 1.3 ml · kg⁻¹ · min⁻¹) before, during and after heat acclimatization. Subjects cycled a maximum of 2 h at 40% $\dot{V}O_{2\max}$ at 45°C dry-bulb temperature, 23°C wet-bulb temperature for 11 days. Prior to acclimatization there were no sexual differences for performance time, rate of increase of rectal temperature (ΔT_{re}), or sweat rate per °C increase of rectal temperature ($m_{sw}/\Delta T_{re}$). Sweat rate (m_{sw}) was greater for the men than for the women. Although there was no difference in the rate of increase of heart rate (ΔHR), HR for women was maintained 15-20 beats · min⁻¹ higher than for the men. Acclimatization occurred for both sexes by reduced T_{re} and HR and increased m_{sw} and performance time. With acclimatization the women had longer performance times than the men. Even though the men still had greater m_{sw} , ΔT_{re} was also greater; therefore $m\Delta T_{re}$ for the men was less than for the women. Neither HR nor ΔHR was different between the sexes. Throughout, resting hematocrit for the women was less than for the men; no changes in hematocrit were observed during exercise or with acclimatization. Plasma protein concentration increased during exercise on all days; no changes in plasma osmolality were observed. It is concluded that active women perform

exercise of equal relative intensity in dry heat as well as active men. Moreover, active women acclimatize to heat at a faster rate or to a greater extent than do active men.

16. Fine, B.J. Field-dependence and color discrimination ability in females. Perceptual and Motor Skills, 57:983-986, 1983.

Previous research has shown that field-independent males are very superior to field-dependent males in ability to discriminate colors. The research reported here examined the same relationship with females. Thirty females were tested twice on the Farnsworth-Munsell 100-Hue Test. As predicted, field-independent females, as a group, performed significantly better on the task than did field-dependent females.

17. Knapik, J.J., Burse, R.L. and Vogel, J.A. Height, weight, percent body fat, and indices of adiposity for young men and women entering the U.S. Army. Aviation, Space, and Environmental Medicine, 54:223-231, 1983.

The purpose of this investigation was to describe the height (H), weight (W), and percent body fat (%BF) of young men and women (ages 17-35 years) entering the U.S. Army and to determine an index of adiposity that fit criteria described in the literature. H and W were measured with a digital scale and anthropometer, respectively. Percent BF was calculated from four skinfolds' thickness. Men and women were both separated into four age categories. Very little difference in H was found with increasing age. W and %BF increased progressively with age in the males but no increase in either parameter was seen within the three youngest age groups of women. For males, W/H^2 was found to be the most appropriate index of adiposity of those studied, having a correlation with %BF of 0.75 and a standard error of estimate of $\pm 3.4\%$ BF. $W/H^{1.5}$ was the most appropriate index for females, having a correlation with %BF of 0.69 and a standard error of estimate of $\pm 3.2\%$ BF. It was suggested that these indices could be used to replace or supplement the

current H-W charts used in the Army. A table for predicting %BF from these indices has been provided.

18. Sawka, M.N., Toner, M.M., Francesconi, R.P. and Pandolf, K.B. Hypohydration and exercise: effects of heat acclimation, gender, and environment. Journal of Applied Physiology: Respiratory, Environmental and Exercise Physiology, 55:1147-1153, 1983.

This study examined the effects of heat acclimation and subject gender on treadmill exercise in comfortable (20°C, 40% rh), hot-dry (49°C, 20% rh), and hot-wet (35°C, 79% rh) environments while subjects were hypo- or euhydrated. Six male and six female subjects, matched for maximal aerobic power and percent body fat, completed two exercise tests in each environment both before and after a ten-day heat acclimation program. One exercise test was completed during euhydration and one during hypohydration (-5.0% from baseline body weight). In general, no significant ($P > 0.05$) differences were noted between men and women at the completion of exercise for rectal temperature (T_{re}), mean skin temperature (T_{sk}), or heart rate (HR) during any of the experimental conditions. Hypohydration generally increased T_{re} and HR values and decreased sweat rate values while not altering T_{sk} values. In the hypohydration experiments, heat acclimation significantly reduced T_{re} (0.19°C) and HR (13 beats · min⁻¹) values in the comfortable environment, but only HR values were reduced in hot-dry (21 beats · min⁻¹) and hot-wet (21 beats · min⁻¹) environments. The present findings indicated that men and women respond in a physiologically similar manner to hypohydration during exercise. They also indicated that for hypohydrated subjects, heat acclimation decreased thermoregulatory and cardiovascular strain in a comfortable environment, but only cardiovascular strain decreased in hot environments.

19. Skinar, G.S., Ingram, S.P. and Pandolf, K.B. Effect of endurance training on perceived exertion and stress hormones in women. Perceptual and Motor Skills, 57:1239-1250, 1983.

Fifteen women (20- to 23-yr-old), engaged in an intensive six to eight-week endurance running program; progressively increased distance from 20 miles during the first week to 50 miles during the fifth week, and thereafter. Before (T1), during (T2), and after training (T3), submaximal treadmill runs of 1-hr duration subdivided into three successive 20-min segments were completed at approximately 60, 70, and 80% of maximal oxygen uptake, respectively. Ratings of perceived exertion (RPE) were differentiated to obtain local (L), central (C), and over-all (O) responses during these 20-min segments. Subjects rated the effort during the final 30 sec of each 5-min interval. Upon completion of each exercise segment, blood samples were drawn for analysis of lactate (Hla), epinephrine (E), and norepinephrine (NE) to determine the relationship between the differentiated RPEs and these stress markers. Endurance training significantly lowered central and over-all ratings of perceived exertion between T1 and T3 runs, but no change occurred in the L-RPE responses to muscular and joint strain. Significant correlations between the stress markers and RPE pooled across sessions were observed during the three treadmill sessions (Hla vs L-RPE, $r = 0.68$; E vs C-RPE, $r = 0.54$; and NE vs C-RPE, $r = 0.63$). These findings indicate that central and over-all ratings of perceived exertion may be more readily influenced by intensive endurance training than local ratings. In addition, while lactate levels may be related to local ratings of perceived exertion, catecholamine levels appear to be associated with central ratings.

20. Sawka, M.N., Francesconi, R.P., Pimental, N.A., and Pandolf, K.B. Hydration and vascular fluid shifts during exercise in the heat. Journal of Applied Physiology: Respiratory, Environmental and Exercise Physiology, 56:91-96, 1984.

This study examined the effects of hypohydration on plasma volume and red cell volume during rest in a comfortable (20°C, 40% relative humidity) and

exercise in a hot-dry (49°C, 20% relative humidity) environment. A group of six male and six female volunteers [matched for maximal O_2 uptake ($\dot{V}O_{2\max}$)] completed two test sessions following a ten-day heat acclimation program. One test session was completed when subjects were euhydrated and the other when subjects were hypohydrated (-5% from base-line body wt). The test sessions consisted of rest for 30 min in a 20°C antechamber, followed by two 25-min bouts of treadmill walking (approx. 30% of $\dot{V}O_{2\max}$) in the heat, interspersed by 10 min of rest. No significant differences were found between the genders for the examined variables. At rest, hypohydration elicited a 5% decrease in plasma volume with <1% change in red cell volume. During exercise, plasma volume increased by 4% when subjects were euhydrated and decreased by 4% when subjects were hypohydrated. These percent changes in plasma volume values were significantly ($P < 0.01$) different between the euhydration and hypohydration tests. Although red cell volume remained fairly constant during the euhydration test, these values were significantly ($P < 0.01$) lower when hypohydrated during exercise. We conclude that hydration level alters vascular fluid shifts during exercise in a hot environment; hemodilution occurs when euhydrated and hemoconcentration when hypohydrated during light intensity exercise for this group of fit men and women.

21. Falkel, J.E., Sawka, M.N., Levine, L. and Pandolf, K.B. Upper to lower body muscular strength and endurance ratios for women and men. Ergonomics, 28:1661-1670, 1985.

This study examined possible gender differences for relative upper (elbow) to lower (knee) body strength and endurance, as well as relative flexion to extension strength and endurance. Seven women and nine men who were matched for both upper and lower body aerobic power were tested on an isokinetic strength instrument. Absolute isokinetic strength was lower ($P < 0.01$) for the women than the men for all measurements. When strength was expressed per lean body weight, the women were weaker ($P < 0.05$) only for elbow flexion strength. The women had a lower ($P < 0.05$) upper to lower body strength ratio for flexion, but not for extension. There were also no differences

($P > 0.05$) in isokinetic endurance fatigue decrements, or upper to lower body endurance ratios between genders. These data indicated that there were differences in absolute strength between the genders, but strength per lean body weight, as well as upper to lower body ratios for strength and endurance were similar for both genders.

22. Pandolf, K.B., Sawka, M.N. and Shapiro, Y. Physiological differences between men and women in exercise-heat tolerance and heat acclimation. Fourteenth Commonwealth Defence Conference on Operational Clothing and Combat Equipment, Melbourne, Australia, 1-25, 1985.

The responses of men to changes in environmental temperature have provided a basis for the understanding of human heat tolerance and thermoregulation. There appears to be less certainty about the thermoregulatory patterns of women. Physiological responses to heat stress may differ between genders due to several factors which include the lower cardiorespiratory fitness, higher body fat content, lower body weight, and lower skin surface area and higher surface area-to-mass ratio of women compared to men. In addition, fluctuating hormonal levels of estrogen and progesterone accompanying the menstrual cycle may influence women's tolerance to heat stress. Since the U.S. Army is currently composed of greater than 10% females, it has become necessary to examine responses of females to exercise-heat stress and heat acclimation. Our Institute has conducted experiments comparing men and women for exercise-heat tolerance and heat acclimation over a wide range of environmental conditions. Both genders have been exposed to a comfortable climate (20°C, 40% RH), several hot-wet (37°C, 80% RH; 35°C, 79% RH; 32°C, 80% RH), and hot-dry (54°C, 10% RH; 49°C, 20% RH) environments while performing various exercise-rest cycles ranging from two to four hours in duration. Genders were matched for aerobic fitness, surface-area-to-mass ratio and/or percent body fat. During the two hour hot-dry exposures, heart rate and core temperature were generally lower for males than females, while no differences in sweat loss were observed. During hot-wet exposures, core temperature and sweat loss were generally lower in females

than males. These data indicate that females and males react in a physiologically similar manner under comfortable environmental conditions, while females seem to tolerate hot-wet climates slightly better than males, and males tolerate hot-dry conditions slightly better. In subsequent experimentation, significant differences were not generally found between the genders for heart rate, core temperature and sweat loss during additional hot-wet and hot-dry exposures. Further, males and females acclimated to a representative hot-dry environment (49°C, 20% RH) at the same rate. In spite of similar rates of achieving heat acclimation, final core and mean skin temperatures remained higher for the females after acclimation as well as before acclimation. These same heat-acclimated men and women were exposed to these same hot-dry conditions (49°C, 20% RH) for four rather than two hours to determine the effect of prolonged exercise in the heat on physiological differences between the genders. It was concluded that prolonged exposure to exercise-heat stress did not enhance physiological differences in responses to dry-heat exposure. Also, when hypohydrated (5% of baseline body weight), during exercise in either a comfortable (20°C, 40% RH), hot-wet (35°C, 79% RH), or hot-dry (49°C, 20% RH) environment, men and women respond in a physiologically similar manner. In conclusion, when genders are similar with regard to aerobic fitness level, surface-area-to-mass ratio and per cent body fat, they do not differ dramatically in exercise-heat tolerance and rate of heat acclimation; these reactions are not altered between the genders when hypohydrated.

23. Falkel, J.E., Sawka, M.N., Levine, L., Pimental, N.A. and Pandolf, K.B. Upper-body exercise performance: comparison between women and men. Ergonomics, 29:145-154, 1986.

This study compared upper-body (arm crank) aerobic fitness for a group of women (n=8) and men (n=9) matched for lower-body (cycle) aerobic fitness. ($\bar{X} \pm \text{S.E.} = 50 \pm 2 \text{ ml kg}^{-1} \text{ min}^{-1}$) and also examined the influence selected physiological factors had on upper-body exercise performance. The components of upper-body exercise studied included maximal power output (PO_{max}), peak oxygen uptake (VO_2), elbow isokinetic strength and endurance,

arm volume and endurance time at 80% arm crank peak VO_2 . During maximal effort upper-body exercise, there was no difference in peak VO_2 ($\text{ml kg}^{-1} \text{ min}^{-1}$) between the genders despite the men's significantly greater strength, arm volume and PO_{max} . Likewise, there was no difference in upper body endurance time at 80% peak VO_2 between the genders. These data indicated that women are not at a disadvantage in performing aerobic upper-body exercise (ii) skeletal muscle strength provides a relatively minor influence on both maximal effort and prolonged upper-body exercise; and (iii) individuals can perform prolonged upper-body exercise at relative intensities greater than that needed to elicit an aerobic training effect.

24. Jones, B.H., Knapik, J.J., Daniels, W.L. and Toner, M.M. The energy cost of women walking and running in shoes and boots. Ergonomics, 29:439-443, 1986.

The purpose of this study was to determine the difference in energy cost for women walking and running in shoes versus heavier boots. Seven subjects wore athletic shoes (mean weight= 514 ± 50 g) and leather military boots (mean weight= 1371 ± 104 g) at three walking speeds (4.0, 5.6 and 7.3 km/hour) and two running speeds (8.9 and 10.5 km/hour). The VO_2 for women wearing boots were significantly higher ($P < 0.05$) than for shoes for both walking and running, with the exception of the slowest walking speed. The average increment in energy cost was 1.0% per 100g increase in weight per pair of footwear. These results are similar to those reported for men from other studies which found increments in energy cost of 0.7 to 0.9% per 100g increase in weight of footwear.

25. Murphy, M.M., Patton, J.F. and Frederick, F.A. Comparative anaerobic power of men and women. Aviation, Space, and Environmental Medicine, 57:636-641, 1986.

The purpose of this study was to determine the differences in anaerobic

power (AnP) between men and women and the contribution of anthropometric variables in accounting for these differences. There were 18 female and 19 male subjects who performed the 30-s Wingate test where power outputs in watts are expressed as mean power (MP, the mean for 30s) and peak power (PP, the highest 5-s interval). Thigh volume (TV), lean body mass (LBM) and body weight (BW) were used as anthropometric variables. Absolute AnP of men was 35% and 40% higher ($p < 0.001$) than that of women for PP and MP, respectively. These differences decreased to 10% and 17% for PP and MP when expressed relative to kg LBM. Anthropometric variables explained less than 50% of the variation in PP and MP for men, while in women, TV accounted for 66% and 71% of the variation in PP and MP, respectively. When the data were combined, TV, BW and LBM explained 48%, 74% and 79% of variation in MP and 53%, 71%, and 76% in PP, respectively. These data show that gender differences in indices of AnP are similar to those reported for muscular strength and aerobic power. Additionally, a larger portion of the between gender variation compared to the within gender variation in AnP can be accounted for by anthropometric variables.

26. Schnakenberg, D.D., Carlson, D., Sawyers, M., Vogel, J., Johnson, R.F., Szlyk, P.C., Francesconi, R. and Hubbard, R.W. Nutritional evaluation of a new combat field feeding system for the Army. In: Proceedings of the Army Science Conference, 4:69-80, 1986.

This report summarizes the findings of the 1985 field evaluation of the Combat Field Feeding System conducted at Pohakuloa, Hawaii. Personnel from the 25th Infantry Division were employed for the test, divided into six treatment groups, evaluating various combinations of tray pack and MRE meal combinations. One treatment group consisted entirely of women from the Division Support Command. Responses to the feeding treatments were evaluated in two phases of 21 and 28 days, respectively. Dependent measurers included nutrient intakes, energy balance, hydration status, nutritional status, food disorders, muscle strength and endurance, body

composition, eye-hand coordination, food acceptance, morale and unit cohesion.

27. Vogel, J.A., Patton, J.F., Mello, R.P. and Daniels, W.L. An analysis of aerobic capacity in a large United States population. Journal of Applied Physiology, 60:494-500, 1986.

This study presents a description of aerobic capacity in a large U.S. population comprised of 1,514 men and 375 women. New male and female recruits representing a young civilian population entered the service with maximal O_2 uptake of 51 and 37 ml.kg body wt⁻¹.min⁻¹, respectively, and thereafter increased 5% during initial basic training. The difference between genders, 30% on an absolute basis, was 14% when expressed as a function of fat-free weight.

28. Fine, B.J. Heat, chemical protective clothing and mental performance of female soldiers. In: Proceedings of the Military Testing Association, Ottawa, Canada, 481-486, 1987.

The data indicate that after three hours in a moderately hot environment, a group of highly trained female soldiers, clad in MOPPIV, showed a marked decrease in the capability of sustaining mental performance. Of the 17 soldiers tested, two were evacuated from the heat in the third hour of exposure, three in the fourth and five in the fifth. The remaining seven participants showed no adverse effects of heat on the performance of any task. No differences were found between casualties and non-casualties in core temperatures or in water consumed during the heat exposure. The performance of a majority of the participants was adversely affected by simply wearing the MOPP gear, despite having undergone eight hours of practice on the tasks while wearing the gear. Reasons for the adverse effects of the gear on performance are uncertain at the present time.

29. Hodgdon, J.A., and Fitzgerald, P.I. Validity of impedance predictions at various levels of fatness. Human Biology, 59:281-298, 1987.

Results of whole body electrical resistance (RES) measurements have been proposed as estimates of total body water and of fat-free mass. The validity of RES to predict percent body fat (%BF) was evaluated in a sample of 403 male and 135 female military personnel. There was general over-prediction of individuals having lower %BF values and under-prediction of individuals having higher %BF values using equations supplied by the manufacturer of the RES measurement device. This problem of non-generalizability was not alleviated by 1) re-determination of regression constants using the variables contained in the manufacturer's equations of this particular sample; 2) incorporation of anthropometric variables in models involving RES and stature; and 3) weighing of the cases to provide equal power at all percent body fat values.

30. Kolka, M.A., Stephenson, L.A., Rock, P.B. and Gonzalez, R.R. Local sweating and cutaneous blood flow during exercise in hypobaric environments. Journal of Applied Physiology, 62:2224-2229, 1987.

The effect of acute hypobaric hypoxia on local sweating and cutaneous blood flow was studied in four men and four women (follicular phase of menstrual cycle), who exercised at 60% of their altitude-specific peak aerobic power for 35 min at barometric pressures (PB) of 770 Torr (sea level), 552 Torr (2,596 m), and 428 Torr (4,575 m) at an ambient temperature of 30° C. There were no gender differences in the sensitivity (slope) or the threshold of either $m_{\text{sk}}/T_{\text{sk}}$ or $SkBF/T_{\text{sk}}$ at any altitude. Autonomic effector function may not be all that different between women studied in the follicular phase of their menstrual cycles and men. These thermoregulatory responses of men and women are similar during exercise and moderate heat stress when the women are in the follicular phase of the menstrual cycle, at the same relative exercise intensity, and in men and women who had trained for a similar number of years.

31. Pandolf, K.B., Toner, M.M., McArdle, W.D., Magel, J.R. and Sawka, M.N. Influence of body mass, morphology, and gender on thermal responses during immersion in cold water. In: Proceedings 9th International Symposium on Underwater and Hyperbaric Physiology, Undersea and Hyperbaric Medical Society, Bethesda, MD, 145-152, 1987.

This review summarizes recent experimental observations under contract and from our laboratory on the influence of body mass, morphology, and gender on the thermal and metabolic responses during both rest and exercise after cold-water exposure. The findings suggest that water temperature, body mass and type and intensity of exercise are more critical factors to be considered in preventing a decline in deep body temperature during cold-water immersion than are the factors of surface-area-to-mass ratio and gender.

32. Kolka, M.A. and Stephenson, L.A. Exercise thermoregulation after prolonged wakefulness. Journal of Applied Physiology, 64:1575-1579, 1988.

The effect of 33 h of wakefulness on the control of forearm cutaneous blood flow and forearm sweating during exercise was studied in three men and three women. Subjects exercised for 30 min at 60% peak O_2 consumption while seated behind a cycle ergometer ($T_a = 35^\circ\text{C}$, $P_w = 1.0$ kPa). We measured esophageal temperature (T_{es}), mean skin temperature, and arm sweating continuously and forearm blood flow (FBF) as an index of skin blood flow, twice each minute by venous occlusion plethysmography. During steady-state exercise, T_{es} was unchanged by sleep loss. The sensitivity of FBF to T_{es} was depressed an average of 30% ($P < 0.05$) after 33 h of wakefulness with a slight decrease (-0.15°C , $P < 0.05$) in the core temperature threshold for vasodilatory onset. Sleep loss did not alter the T_{es} at which the onset of sweating occurred; however, sensitivity of arm sweating to T_{es} tended to be lower but was not significant. Arm skin temperature was not different between control and sleep loss experiments. Reflex cutaneous vasodilation during exercise appeared to be reduced by both central and local factors after 33 h of wakefulness.

33. Segal, K.R., Van Loan, M., Fitzgerald, P.I., Hodgdon, J.A. and Van Itallie, T.B. Lean body mass estimation by bioelectrical impedance analysis: a four-site cross-validation study. American Journal of Clinical Nutrition, 47:7-14, 1988.

This study validated further the bioelectrical impedance analysis (BIA) method for body composition estimation. At four laboratories densitometrically-determined lean body mass (LBMd) was compared with BIA in 1567 adults (1069 men, 498 women) aged 17-62 y and with 3-56% body fat. Equations for predicting LBMd from resistance measured by BIA, height², weight, and age were obtained for the men and women. Application of each equation to the data from the other labs yielded small reductions in *R* values and small increases in SEEs. Some regression coefficients differed among labs but these differences were eliminated after adjustment for differences among labs in the subjects' body fatness. All data were pooled to derive fatness-specific equations for predicting LBMd: the resulting *R* values ranged from 0.907 to 0.952 with SEEs of 1.97-3.03 kg. These results confirm the validity of BIA and indicate that the precision of predicting LBM from impedance can be enhanced by sex- and fatness-specific equations.

34. Stephenson, L.A. and Kolka, M.A. Effect of gender, circadian period and sleep loss on thermal responses during exercise. In: Human Performance Physiology and Environmental Medicine at Terrestrial Extremes. K.B. Pandolf, M.N. Sawka and R.R. Gonzalez (Eds.), Benchmark Press, Indianapolis, IN, 267-304, 1988.

This review addresses how gender, the circadian period and sleep loss affect human thermoregulation. Differences in thermoregulation between males and females are discussed. In addition, effects of the menstrual cycle on temperature regulation are reviewed. Thermoregulation in women of reproductive age is characterized by an increased core temperature threshold for onset of all thermoregulatory effectors during exercise, heat exposure and cold exposure during the luteal phase compared to the follicular phase of the menstrual cycle. Higher core temperature thresholds for onset of thermoregulatory effector function is consistent with increased set-point

temperature in the luteal phase. The circadian core temperature rhythm is regulated by changes in the core temperature thresholds for onset of sudomotor and vasomotor responses, which is consistent with the hypothesis that the thermoregulatory reference signal(s) oscillate(s) in a circadian rhythm. As long as the heat loss effectors are tightly coupled to the core temperature rhythm (internal synchronization) there is no evidence that the circadian cycle impairs the homeostatic mechanism of thermoregulation. The extended loss of sleep (<30 hours) is associated with an attenuation in the effector responses for heat dissipation during exercise. In summary, the critical evaluation of thermoregulatory responses to an altered thermal drive, whether it is endogenous or exogenous in origin, must include controls of the menstrual and circadian cycles as well as sleep status.

35. Stephenson, L.A. and Kolka, M.A. Plasma volume during heat stress and exercise in women. European Journal of Applied Physiology and Occupational Physiology, 57:373-381, 1988.

Five women were studied during exercise and passive heating to determine whether plasma volume (PV) dynamics were affected by the menstrual cycle. The exercise bout (80% V_{O_2} peak) on a modified cycle ergometer and the passive heat stress were done in a hot environment ($T_a = 50^\circ\text{C}$, $P_w = 1.61$ kPa) during the follicular and luteal phase. During passive heating, PV decreased by a mean volume of $156(\pm 80)$ ml to $2.83(\pm 0.09)$ l in the follicular phase. During the luteal phase, there was a larger volume reduction (300 ± 100 ml) during passive heating, and the final PV was lower than in the follicular phase and averaged 2.47 ± 0.18 l. During exercise, PV decreased $463(\pm 90)$ ml to $2.50(\pm 0.11)$ l in the follicular and $381(\pm 70)$ ml to $2.50(\pm 0.23)$ l in the luteal phase. These data indicate that there is a menstrual cycle effect on PV dynamics during passive heating such that more fluid is shifted out of the vasculature during the luteal phase. During severe exercise there is greater fluid loss during the follicular phase, yet the final PV is not different between phases.

36. Kolka, M.A., Stephenson, L.A. and Gonzalez, R.R. Depressed sweating during exercise at altitude. Journal of Thermal Biology, 14:167-170, 1989.

The physical effect of a hypobaric environment was studied in four men and four women acutely exposed to both moderate (552 Torr) and high (428 Torr) altitude. We evaluated local sweating at three distinct skin sites during light and moderate exercise. The female subjects were studied only during the early follicular phase of their menstrual cycle. There were no differences in measured thermoregulatory responses to moderate and high altitude between male and female subjects. All individuals were habitual exercisers and by controlling exercise intensity, time of day, and menstrual cycle phase, it was possible to evaluate the genders simultaneously and show similar responses in the simulated hypobaric environment. Resting esophageal temperature was lower at high altitude compared to sea level. Whole body skin wettedness was lower at both moderate and high altitude. The esophageal temperature threshold for sweating onset, although different from site to site, was not affected by acute hypobaric hypoxia. A general suppression in the thermosensitivity for sweating consistent with changing peripheral input to the sweat glands was seen at both moderate and high altitude.

37. Kolka, M.A. and Stephenson, L.A. Control of sweating during the human menstrual cycle. European Journal of Applied Physiology and Occupational Physiology, 58:890-895, 1989.

The elevation in resting core temperature during the luteal phase of the human menstrual cycle is believed to be a consequence of altered control of peripheral heat loss mechanisms (sweating and cutaneous vasodilation). Thermoregulatory responses were studied in seven women at rest and during severe exercise (80% peak $\dot{V}O_2$) in a hot environment (50°C). Experiments were done in the early follicular and the mid-luteal phases of the menstrual cycle. In addition, subjects were studied in a warm environment (35°C) at 85% peak $\dot{V}O_2$ in both early follicular and mid-luteal phases of their menstrual cycle. The normal luteal phase elevation in resting core temperature occurred in all

subjects during all experimental protocols. At rest and during severe exercise (in both warm and hot environments) the esophageal temperature threshold for sweating onset was higher in the luteal phase compared to the follicular phase. This rightward or upward shift in esophageal temperature averaged (0.5°C) for all experiments. These data indicate that the regulation of body temperature is affected by the human menstrual cycle as the esophageal temperature threshold for heat loss (sweating) is shifted upward to maintain core temperature at an elevated level in the luteal phase of the menstrual cycle.

38. Stephenson, L.A., Kolka, M.A., Francesconi, R. and Gonzalez, R.R. Circadian variations in plasma renin activity, catecholamines and aldosterone during exercise in women. European Journal of Applied Physiology and Occupational Physiology, 58:756-764, 1989.

In recent years there has been an enormous research effort to identify, describe and determine the significance of circadian rhythms in many physiologic systems. Four women were studied in the early morning (0400 h) and mid-afternoon (1600 h) to determine if their hormonal and hemodynamic responses to exercise varied with the circadian cycle. Each subject was studied in the early follicular and the mid-luteal phase of her menstrual cycle. During moderate exercise, the relative hemoconcentration was similar between early morning and afternoon, although the absolute plasma volume was lower in the afternoon. Plasma renin activity (PRA) was unchanged by time of day, however during exercise PRA increased ~250% in the afternoon compared to ~100% in the morning. The normal circadian rhythms in plasma aldosterone and plasma cortisol were observed. In conclusion, the circadian rhythms in esophageal temperature, plasma volume, blood constituents, aldosterone and cortisol were maintained during exercise, although exercise itself elicited significant changes in most of these variables. In contrast, the circadian rhythm in the catecholamines at rest was obscured during exercise. Finally, the PRA response during exercise almost doubled in the afternoon experiments compared to morning experiments, and appeared to be dissociated from the aldosterone response.

39. Friedl, K.E., Vogel, J.A. and Jones, B.H. Assessment of body weight standards in Army recruits. In: Proceedings of the Army Science Conference, Durham, NC, July 1990.

We investigated the effect of the current accession weight standards on the Army Weight Control Program. Height, weight, and circumferences necessary to estimate body fat using the Army equations were measured on new recruits at Fort Jackson. Six months after basic training, a follow-up survey was conducted with the assistance of the unit commanders. The results demonstrate a marked difference in the impact of both the accession weight and retention fat standards on male and female recruits. Although the accession weight tables for males permit entry of virtually all otherwise qualified male recruits, the accession weight tables for females exclude 32% of female candidates due to the close proximity of the weight standard to the national average. At entry on active duty (EAD), a smaller proportion of males (22.6%) than females (30.6%) exceed retention fat standards, although only a few females (5.2%) exceed their fat standards by more than 4% body fat units. During basic training, lean males gained weight while overfat males lost weight. This trend continued for males after basic training with the proportion of overfat males dropping to 13.3%. Weight loss in females reversed, and six months after basic training, females had gained 4.9 ± 5.5 lbs from their EAD weight and the proportion of overfat females (30.7%) was no different than at EAD. These data indicate that the differential success for males and females in meeting weight control standards can be attributed partly to mismatches between accession and retention standards and body composition of the respective populations, and perhaps, to some sex-based difference in ability to achieve or maintain current target body fat standards.

40. Fine, B.J. and McCord, L. Oral contraceptive use, caffeine consumption, field-dependence and the discrimination of colors. Perceptual and Motor Skills, 73:931-941, 1991.

We attempted to validate laboratory research which indicated that single

doses of oral contraceptives (OCs) and caffeine affect the ability to discriminate colors (Bohme & Bohme, 1985). We did this in a nonlaboratory setting by surveying habitual use of OCs and caffeine by 43 female college students and relating that information to their performance on the Farnsworth-Munsell 100 Hue Test. When field-dependence, conceptualized as an indirect measure of sensitivity of the nervous system and previously shown to be strongly related to color discrimination, was included in the analyses, the results supported Bohme and Bohme's findings. For Trays 2 and 3 of the 100-Hue Test (yellow through blue of the color spectrum), higher caffeine consumption among OC users was related to poorer color discrimination, whereas, among nonusers of OCs, it was related to better performance. Study design limitations do not permit attribution of causation to either caffeine or OCs at this time.

41. Knapik, J.J., Bauman, C.L., Jones, B.H., Harris, J.M, and Vaughan, L. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. American Journal of Sports Medicine, 19:76-81, 1991.

One hundred thirty-eight female collegiate athletes, participating in eight weight bearing varsity sports, were administered preseason strength and flexibility tests and followed for injuries during their sports seasons. Strength was measured as the maximal isokinetic torque of the right and left knee flexors and knee extensors at 30 and 180 deg/sec. Flexibility was measured as the active range of motion of several lower body joints. An athletic trainer evaluated and recorded injuries occurring to the athletes in practice or competition. Forty percent of the women suffered one or more injuries. Athletes experienced more lower extremity injuries if they had: 1) a right knee flexor 15% stronger than the left knee flexor at 180 deg/sec; 2) a right hip extensor 15% more flexible than the left hip extensor; 3) a knee flexor/knee extensor ratio of less than 0.75 at 180 deg/sec. There was a trend for higher injury rates to be associated with knee flexor or hip extensor imbalances of 15% or more on either side of the body. These data demonstrate that specific strength and flexibility imbalances are associated with lower extremity injuries in female collegiate athletes.

42. Kraemer, W.J., Gordon, S.E., Fleck, S.J., Marchitelli, L.J., Mello, R.R., Dziados, J.E., Friedl, K., Harman, E., Maresh, C. and Fry, A.C. Endogenous anabolic hormonal and growth factor responses to heavy resistance exercise in males and females. International Journal of Sports Medicine, 12:228-235, 1991.

To examine endogenous anabolic hormonal responses to two different types of heavy resistance exercise protocols (HREPs), eight male and eight female subjects performed two randomly assigned protocols (i.e., P-1 and P-2) on separate days. Each protocol consisted of eight identically ordered exercises carefully designed to control for load, rest period length, and total work (J) effects. P-1 utilized a 5-RM load, 3-min rest periods and had lower total work than P-2. P-2 utilized a 10-RM load, 1-min rest periods and had a higher total work than P-1. Whole blood lactate and serum glucose, human growth hormone (hGH), testosterone (T), and somatomedin-C [SM-C] (i.e., insulin-like growth factor 1, IGF-1) were determined pre-exercise (i.e., after 4 of the 8 exercises), and at 0, 5, 15, 30 and 60 min post-exercise. Males demonstrated significant ($p < 0.05$) increases above rest in serum T values, and all serum concentrations were greater than corresponding female values. Growth hormone increases in both males and females following the P-2 HREP were significantly greater at all time points than corresponding P-1 values. Females exhibited significantly higher pre-exercise hGH levels compared to males. The P-1 exercise protocol did not result in any hGH increases in females. SM-C demonstrated random significant increases above rest in both males and females in response to both HREPs. These data suggest that the hormonal response patterns to HREPs are variable and in females differ from those males due to significantly higher pre-exercise and exercise-induced serum T levels in males and higher pre-exercise serum hGH concentrations in females.

43. Jones, B.H., Bovee, M.W. and Knapik, J.J. Associations among body composition, physical fitness, and injury in men and women Army trainees. In: Body Composition and Physical Performance: Applications for the Military Services, Chapter 9. Marriott, B.M. and J. Grumstrup-Scott (Eds.), National Academy Press, Washington, D.C., 141-173, 1992.

Data from this study suggest that measures of percent BF are not as good at predicting physical fitness for women as they are for men. For both men and women, physical fitness as measured by even simple techniques such as sit-ups in combination with BF is a better predictor of other types of fitness such as mile run times or other forms of weight-bearing endurance than percent BF alone. Furthermore, higher percentages of BF for men are associated with increased risk of injury, but for women they are not. Physical fitness is a better predictor of injury than BF or gender. Therefore, if physical fitness and freedom from injury are important to the Army, it would make sense to at least include some simple measure of fitness in the screening process for prospective enlistees.

44. Knapik, J.J., Jones, B.H., Bauman, C.L., and Harris, J.M. Strength, flexibility and athletic injuries. Sports Medicine 14:277-288, 1992.

This article critically reviews the scientific evidence of an association between strength, flexibility and athletic injuries in both women and men, along with the criteria used to evaluate studies in this area. The potential confounding influence of previous injuries is examined along with the evidence that injuries can be reduced by correcting muscular imbalances through strength training. Studies conducted thus far suggest: 1) there is some evidence that right/left strength imbalances may increase the likelihood of lower body sprains and muscle strains; 2) it may be that either high or low flexibility in the hip/low back region is associated with a higher incidence of lower extremity injuries of different types; and 3) flexibility imbalances in the hip region may be associated with sprains and muscle strains in the lower body. No relationship has been established between absolute strength and athletic injuries, and between antagonistic/agonistic strength ratios and injuries. There is no direct

evidence that correcting right/left imbalances with strength training will reduce injuries.

45. Kolka, M.A. Temperature regulation in women. Medicine, Exercise, Nutrition, and Health, 1:201-207, 1992.

In reviewing thermoregulatory responses of women, most studies indicate a significant upward (higher) shift in the thermoregulatory set point during the luteal phase of the menstrual cycle. This change in the core temperature set point parallels the elevation in resting core temperature, and probably maintains the higher core temperature. Acute thermoregulatory responses are not impaired by this increased set point temperature in the luteal phase. It has been suggested that the "subtle" difference in resting core temperature and elevation of the core temperature thresholds for sweating and vasodilation is of little consequence during exercise heat stress. In fact, during light exercise in hot environments, little difference is seen in exercise core temperature during different menstrual cycle phases. In addition, autonomic effector function may not be all that different between women in the follicular phase and men. The thermoregulatory responses of men and women are similar during exercise and moderate heat stress when the women are in the follicular phase of the menstrual cycle, at the same relative exercise intensity, and in men and women who had trained for a similar number of years. There were no differences found in either the core temperature thresholds or the slopes of skin blood flow and sweating to core temperature between men and women (follicular phase) during the same environmental and exercise stress. In summary, if thermoregulatory effector responses are to be compared between genders, or if both men and women comprise the study population, it is essential that women be studied in the early follicular phase. If women are fit, are acclimated to the specific environment, and are otherwise suited (strength or size issues), there is no thermoregulatory bias to exclude participation by women in exercise tasks.

46. Rice, V.J. A usability assessment of two harnesses for stretcher-carrying. In: Advances in Industrial Ergonomics and Safety IV S. Kumar (Ed.), Taylor & Frances, London, United Kingdom, 1269-1274, 1992.

The purpose of this study was to compare the usability of two harness systems in a field environment. Subjects carried and loaded as many patients as possible in 15 minutes. Three harness conditions were used: 1) no harness, 2) an H-cross design with aluminum "J-hooks" to secure the litter handles (HX-hook), and 3) an H-design with loops to secure the litter handles (H-loop). Results from this indicate the H-cross design is superior to the H-design and that a harness is beneficial for female two-person teams during repeated short carries.

47. Sharp, M.A. and Vogel, J.A. Maximal lifting strength in military personnel. In: Advances in Industrial Ergonomics and Safety IV. S. Kumar (Ed.), Taylor & Frances, London, United Kingdom, 1261-1268, 1992.

Heavy lifting is the most physically demanding task in 90% of all military job specialties. While there is a well used data base for their anthropometric measurements, there is little published information concerning the lifting strength of military personnel. The maximal lifting strength of 2067 male and 1301 female soldiers was measured. Maximal lifting strength was the heaviest load lifted to 152 cm using a weight stack machine. This paper describes the maximal lifting strength of U.S. Army personnel as a function of gender, age, body composition and career status.

48. Vogel, J.A. Obesity and its relation to physical fitness in the U.S. Military. Armed Forces and Society, 18:497-513, 1992.

This review addresses the basis for the military's requirements for maximal weight for height and body fat standards. Particular emphasis is given to the relationship between body weight and body composition to physical

fitness and physical performance of military jobs. Both theoretical and practical relationships between physical performance and body fat and muscle mass are described. Body composition differences between genders is described and how this influences the establishment of weight and fat standards based on performance.

49. Vogel, J.A. and Friedl, K.E. Army data: body composition and physical capacity. In: Body composition and Physical Performance, Chapter 6. B.M. Marriott and J. Grumstrup-Scott (Eds), National Academy Press, 89-103, 1992.

This review article summarizes the research studies that have been conducted by this Institute regarding the relationship between body composition, particularly body fat and fat-free mass, and physical performance. This research has shown that body fat content is related negatively to aerobic fitness when expressed relative to body weight and measured in terms of body mobility, such as running. Fat-free mass, representing largely skeletal muscle mass, is related to the performance of strength type tasks such as lifting capacity. Body fat and fat-free mass account for approximately one-third of the variability in aerobic capacity and lifting capacity, respectively. Current body composition standards for both genders have been adjusted so that they correspond to physical fitness standards. Particular attention and adjustment has recently been carried out on the standards for women so that resulting body fatness and muscle mass levels achieve desired physical performance levels while still meeting acceptable appearance standards.

50. Vogel, J.A. and Friedl, K.E. Body fat assessment in women. Special considerations. Sports Medicine, 13:245-269, 1992.

This review identifies the issues which should be taken into account in the measurement of women's body composition. Compared to men, fat regulation in women is considerably more elaborate, with more and different sites for storage and a larger proportion of fat distributed to the extremities and

in subcutaneous locations. This complicates anthropometric prediction of total fatness and clearly limits the generalizability of any female equation. Anthropometric methods are further confounded by difficulties in the criterion methods against which they are developed. Assumptions about fractional contributions of bone mineral and body water to fat-free mass and density may not hold through the reproductive cycles. Other factors include athletic amenorrhea and menopause. Total body fat reflects a more complex regulation and has a different meaning to health and performance in women than it does for men.

51. Williamson, T.L. and Rice, V.J. Re-evaluation of the Caldwell Regime: the effect of instruction on handgrip strength in men and women. In: Advances in Industrial Ergonomics and Safety IV. S. Kumar (Ed.), Taylor & Frances, London, United Kingdom, 675-682, 1992.

This study evaluated the effect of instruction on handgrip strength in males and females and re-evaluated the Caldwell Regimen for measuring grip strength. Three sets of handgrip instructions were used to evaluate 18 men and 17 women, ranging in age from 18 to 31 years. The recruits showed, unlike previous measurements on finger pinch strength, that subjects were able to maintain the $\pm 10\%$ bandwidth and that different instructions for force generation resulted in varying maximal grip force. Therefore, instructions used should be precise, consistent, reported along with the results, and reflect the intended use of the data.

TECHNICAL REPORTS

NOTE: Copies of the following reports may be obtained by writing to the Commander, US Army Research Institute of Environmental Medicine, Natick, MA 01760-5007

1. Peterson, J.A., Vogel, J.A., Kowal, D.M. and Tomasi, L.F. Project 60: A comparison of two types of physical training programs on the performance of 16-18 year old women. Summary Report, U.S. Military Academy Summary Report, 3 May 1976.

In order to prepare for the law requiring the military academies to open admissions to women beginning in 1976, a study was conducted by the Exercise Physiology Division, USARIEM, and the Physical Education Office, US Military Academy, to determine the necessary adjustments in testing and training to affect this change. The project was called "Project 60", referring to the 60 high school (16-18 year old) volunteers that were recruited from high schools in the West Point area. After extensive physical fitness baseline testing, the group was divided into three subgroups: control with no physical training, strength training group three days per week, and "reveille exercise" training four days per week. Reveille exercise consisted of calisthenics, rifle drill and running that is employed for new plebes during the initial seven-week training at the Academy. Injuries during the seven-week experimental training period were carefully recorded and reported in this report. Physiological responses to the various training programs were evaluated and contrasted during post training repeated tests of fitness.

2. Lloyd, A.J., Allen, P.D. and Cote, M.G. Electromyographic assessment during isokinetic exercise in women. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T3/78, 1978.

Electromyographic (EMG) recordings were made during the assessment

of arm strength and endurance of an isokinetic exercise in 25 high school women participating in a study designed to evaluate the response of young women to a male military training program. Force and EMG records were obtained during maximum voluntary contractions at isokinetic speeds 5 and 15 RPM; and during a 30-sec isokinetic endurance trial at 15 RPM. The results indicated that, regardless of the type of training, arm strength and endurance improved. Furthermore, force increase was accompanied by a significant decrease in EMG activity of the dominant muscles. The results suggested that training facilitated arm strength and endurance through an ability to minimize muscle activity. Type of training regimen was not as important as routine participation in exercise.

3. Vogel, J.A., Wright, J.E., Patton, J.F., Dawson, J. and Eschenback, M. A system for establishing occupationally-related gender-free physical fitness standards. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T5/80, 1980.

The Army's desire to utilize greater numbers of women in physically demanding, non-traditional occupations has created the need to match individual capacities with occupational demands. Research has been conducted to develop a process by which objectively determined physical demands of MOSs can be converted into gender-free physical fitness standards. These standards could then be used both for MOS assignment qualification as well as assuring maintenance of fitness commensurate with job demands. The process was initiated by compiling individual task lists from which cluster of MOSs were formed of those with similar physical demands. The most demanding MOS tasks within each cluster were then measured for their actual physiological cost, force required and/or energy expended, with these costs then being converted into equivalent physiological capacities. These capacities were expressed in terms of muscle strength and aerobic power (stamina) which can be assessed at the time of entrance into the service as well as during periodic on-the-job evaluations. This research has resulted in the derivation of five sets of standards, encompassing three levels of demand

within two categories of fitness (strength and stamina). The process describes a system by which physically demanding occupations can be assigned on a gender-free basis which will be scientifically defensible.

4. Knapik, J.J., Vogel, J.A., and Wright, J.E. Measurement of isometric strength in an upright pull at 38 cm. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report 3/81, 1981.

A procedure and device to measure an isometric upright pull at 38 cm is described. The test was originally designed to be used in the prediction of lifting capability. The equipment includes an electronic load cell (transducer), a mounting platform and a visual readout. The test consists of a maximal voluntary isometric pull from a squatting position and involves a critical point in the range of motion as well as many of the same muscle groups involved in lifting an object from ground level. For a sample of young male and female soldiers the procedures were shown to have a reliability coefficient of 0.97 over three trials. The mean (\pm S.D.) values were 138 ± 24 kg and 84 ± 19 kg for males and females, respectively.

5. Kowal, D.M., Vogel, J.A., Sharp, D. and Knapik, J. Analysis of attrition, retention and criterion task performance of recruits during training. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T2/82, 1982.

This research evaluated aspects of task performance, physical work capacity, biographical data and psychological coping strategies, to determine their relationship to attrition and retention of personnel during a stressful training program. It attempted to develop a selection instrument that could be utilized as part of a pre-training screening device to optimize both personnel selection and subsequent occupational assignment and training in the U.S. Armed Forces. Thirteen hundred men and women recruits were measured at the beginning of a recruit training period. Subsequent discriminant analysis of graduates and dropouts demonstrated significant differences on five variables correctly classifying 30% of the dropouts. These variables included physical

self-comparison, reports of physical ailments (HOS), ability to cope with situational stress (RTLP), body composition and age. When these variables were subjected to a stepwise multiple regression, a predictive validity of .50 and .04 was observed for female and male dropouts, respectively. Likewise, the use of multiple regression for the prediction of criterion task performances resulted in significant multiple Rs ranging from .45 to .67 using strength measurement alone. The results suggest that even with reasonable limitations of the multivariate model, in terms of cost effectiveness, it may be a useful tool for the identification of female dropouts and the prediction of task performance in a stressful training environment. The application of the findings to the personnel recruitment, selection and training process has varied implications.

6. Winsmann, F.R., Bense, C.K., Goldman, R.F. and Pandolf, K.B. Physiological and subjective evaluation of the temperate battle dress uniform (TBDU) and three other uniforms worn by men and women in tropical climatic conditions. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T4/83, 1983.

The most impressive difference between the four uniforms evaluated in the present study was in the Evaporation/Production (E/P) ratios of the various uniforms. Troops wearing the camouflage version of the Hot Weather Combat Uniform (Cam-HW) were able to evaporate 85% of the sweat produced; wearing the Durable Press Utility Uniform (DPU) they were able to evaporate 82%; with the solid green version of the Hot Weather Combat Uniform (OG-HW) they were able to evaporate 79%. None of these three differed significantly or even approached statistically significant differences. However, when the Temperate Battle Dress Uniform (TBDU) was worn, only 71% of the sweat produced was able to be evaporated and the difference, although greater than the 5% level of probability, produced an F value for group differences of 2.3 suggesting that with a larger sample size, or less individual variability, a significant difference might have been obtained between TBDU and all other uniforms. There were no significant differences, or meaningful trends in rectal temperature, mean weighted skin temperature or heart rate between any of the

uniforms during these tests. In summary, the results for this test, for which conditions were selected to maximize the possibility of obtaining physiological differences between the clothing systems, failed to reveal major physiological differences, although as judged from the efficiency of sweat evaporation, the Temperate Battle Dress Uniform (TBDU) with a 71% value required substantially more sweat production per unit of evaporation than did the other uniforms. Women reported that the TBDU was bulky and ill-fitting and were opposed to wearing a camouflaged uniform on a regular basis.

7. Mello, R.P., Murphy, M.M. and Vogel, J.A. Relationship between the Army two mile run test and maximal oxygen uptake. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T3/85, 1985.

Forty-four male (aged 20-51) and seventeen female (aged 20-37) subjects of various fitness and activity levels were evaluated on a two-mile run for time and on a treadmill for a maximal oxygen consumption ($\text{VO}_{2\text{max}}$). The coefficient of correlation between the treadmill maximal test and the two-mile run test for all subjects was -0.91. Separate regression analyses for male and female data also displayed excellent correlation ($r = -0.91$, $r_f = -0.89$). Stepwise, multiple regression analysis of such anthropometric variables as age, height, weight, and % body fat demonstrated that, individually, none of these parameters significantly improved the predictability of both the male and female equations. However, inclusion of body weight in the male equation did improve the predictive accuracy ($\text{SEE} = 3.31$ to 2.69). The high degree of correlation demonstrated between $\text{VO}_{2\text{max}}$ and two-mile run time thus permits the estimation of either component with significant accuracy from the direct measurement of the other. This study confirms the usefulness and validity of the Army's two-mile run for time test to indicate the level of aerobic fitness capacity when the test is properly supervised and the subjects are well-motivated.

8. Teves, M.A., Wright, J.E. and Vogel, J.A. Performance on selected candidate screening test procedures before and after Army Basic and Advanced Individual Training. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T13/85, 1985.

The purpose of this project was to evaluate a strength screening procedure to be used in Military Entrance Processing Stations (MEPS) for matching the strength capacity of recruits with the strength demands of Military Occupational Specialties (MOSs). Prior to the study, a task analysis was performed and all Army MOSs were fit into a five-category modified Department of Labor classification system based on lifting requirements. In order to determine the best single screening test for lifting ability, five-candidate test items were performed by 1,984 Army recruits prior to Basic Training (BT). The tests, chosen for face validity, proven reliability, and historical precedence, were isometric handgrip, isometric 38 cm upright pull, incremental dynamic lift, skinfold determination of body composition, and a submaximal prediction of maximal oxygen uptake. At the end of Advanced Individual Training (AIT) 970 of the same subjects were re-tested on the candidate test items, and on a series of job-related criterion performance tasks (CPTs). Candidate test item norms for male and female soldiers are presented for pre and post BT, and for post-AIT. The two training phases had a significant positive effect on muscle strength, aerobic fitness and body composition. The incremental dynamic lift to 152 cm was found to be the best predictor of CPT performance and was selected for implementation as the Military Entrance Physical Strength Capacity Test (MEPSCAT). An evaluation of the effectiveness of the MEPSCAT is currently in progress and will be reported elsewhere. As less than 15% of the females in the heavy lifting MOS categories were actually strength qualified for their MOS at the end of AIT, one of several conclusions may be drawn: (a) 85% of these females were not capable of completing all MOS tasks; b) the MOS was not properly categorized; c) an inability to lift the required weight on the IDL does not accurately reflect upon job performance. These data clearly show that a need exists for an accurate test of strength capacity prior to MOS assignment.

9. Fitzgerald, P.I., Vogel, J.A., Daniels, W.L., Dziados, J.E., Teves, M.A., Mello, R.P. and Reich, P.J. The body composition project: a summary report and descriptive data. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T5/87, 1986.

Weight control programs in the Armed Forces have received much attention due to recent interest in the development of military physical fitness programs. Prior to April, 1983, the U.S. Army weight control program, regulated by AR 600-9, incorporated height-weight standards as a screen to identify "overweight" soldiers. Height-weight tables suffer from many deficiencies; the most common problem is their inability to differentiate between an overweight state that is due to an abundance of muscle as opposed to excess fat. This issue was addressed in Department of Defense Directive 1308.1 and as a result, Army Regulation 600-9 was revised in April, 1983. The revision included specific instructions for measuring an overweight state in terms of an individual's relative body fat as estimated by the sum of four skinfolds. Shortly after implementation, the validity of the height-weight and body-fat standards as well as the appropriateness of the skinfold methodology was questioned. A study was designed to create a data base with which to validate several components of the Army weight control program. This report contains summary material and descriptive data for the total project. Data (n=72 variables) are analyzed by gender and race with age as a covariate and are presented for 1194 males and 319 females. Measurements included: demographic data, leisure time physical activity data, medical and smoking histories, photographic assessments in class A uniform and swimsuit, underwater weight with vital capacity and residual lung volume, aerobic capacity via treadmill test, maximal lift capacity to 60 inches, 12 skinfolds, 15 circumferences, 9 diameters, visual rating of adiposity, somatotype and Army physical fitness test results.

10. Schnakenberg, D. Combat field feeding system-force development test and experimentation (CFFS-FDTE) Test Report. USACDEC, Fort Ord, California, and USARIEM, Natick, Massachusetts. Test Report CDEC-TR-85-006A, 1986.

This report summarizes the findings of the 1985 field evaluation of the Combat Field Feeding System conducted at Pohakuloa, Hawaii. Personnel from the 25th Infantry Division were employed for the test, divided into six treatments groups, evaluating various combinations of tray pack and MRE meal combinations. One treatment group consisted entirely of women from the Division Support Command. Responses to the feeding treatments were evaluated in two phases of 21 and 28 days, respectively. Dependent measurers included nutrient intakes, energy balance, hydration status, nutritional status, food disorders, muscle strength and endurance, body composition, eye-hand coordination, food acceptance, morale and unit cohesion.

11. Teves, M.A., Vogel, J.A., Carlson, D.E. and Schnakenberg, D.D. Body composition and muscle performance aspects of the 1985 CFFS test. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T12/86, 1986.

A new combat field feeding system (CFFS) has been developed to provide soldiers with one to two hot meals at a minimal labor cost. The tray pack ration (T-ration) which requires no preparation or refrigeration and needs only to be heated is the ration under examination. Soldiers were tested before, during and after a 44-day field exercise to compare the T-ration to various combinations of existing feeding systems. Body composition and muscle strength and endurance were tested before and at days 1, 20 and 24 of the scenario. Skinfold and circumference techniques were used to estimate body composition. Isometric handgrip and 38 cm upright pull and maximum lift capacity were the strength measures collected. Muscular endurance was measured as holding time at 60% maximal handgrip strength. No significant differences were found between diet groups. Results showed an initial

decrease in weight which tended to recover over time. This decrease was almost wholly accounted for by a decrease in percent body fat of 1.5% and 2.5% in men and women, respectively. While no changes were found in arm muscle volume, women actually showed an increase in fat free mass, and 38 cm upright pull increased across time in both men and women. None of the other strength or endurance measures changed significantly over time. It was concluded that consumption of the new CFFS for up to 44 days did not have an adverse impact upon body composition, muscular strength or endurance.

12. Fine, B.J. The effect of heat and chemical protective clothing on the ability of a group of female soldiers to sustain performance of military cognitive tasks. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T7/88, 1987.

We previously have found that chemical protective clothing seriously degraded the performance of sedentary male soldiers doing sustained mental work in the heat. Here in an identical study, we examine the performance of female soldiers in protective clothing. To our knowledge, this is the only controlled study of its kind with women. Eighteen female soldiers trained for two weeks on cognitive tasks resembling those performed by fire direction center, forward observer and communications personnel. Then, they performed the tasks for seven-hour periods on four successive days in hot (91°F., 61% RH) and normal (55°F., 35% RH or 70°F., 35% RH) conditions, with and without chemical protective clothing. The data indicate that after three hours in the hot environment, while clad in MOPP IV, the women, as a group, showed a marked decrease in the ability to sustain performance. Of the seventeen soldiers tested, two had to be evacuated from the heat in the third hour of exposure, three in the fourth and five in the fifth. The remaining seven participants showed no adverse effects of heat and MOPP IV on the performance of any task. No differences were found between heat casualties and non-casualties in core temperatures or in water consumed during the heat exposure. Reasons for evacuation included fainting, about to faint, incoherent responses to questions, feelings of total exhaustion, or an expressed statement by the

participant that she wished to terminate. In terms of unit performance, the necessary evacuation of more than 50% of the "unit" represented by the women in this study, prior to six hours of heat exposure, has serious implications. Additional research is needed to determine whether gender differences observed between this and a previous study with male soldiers reflect basic physical, physiological or psychological differences between sexes or reside in transient factors peculiar to the specific samples involved, such as differences in physical fitness, size, attitude or experience. The performance of a majority of the participants also was adversely affected by wearing MOPP IV at 55°F., despite having had eight hours of practice on the tasks in the gear at that temperature. This result is similar to, but more severe than, that found with male soldiers. Reasons for the adverse affect are unclear, but do not seem to be due to interference of gloves and/or mask with dexterity or vision. The stress of adapting to the novel experimental situation for the first time is posited as a possible explanation. Training personnel to do their jobs in MOPP IV under the most realistic conditions possible is recommended.

13. DeLuca, J.P., Armstrong, L.E., Christensen, E.L., Hubbard, R.W., Vogel, J.A. and Schnakenberg, D.D. Mass-to-surface area ratio in military personnel. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T21/88, 1988.

Mass-to-surface area ratio (M/SA) was calculated from the body weight and skin surface area of 1513 male and female US Army personnel. It has been suggested that M/SA plays a role in thermoregulation, particularly in hot-humid environments, since both body weight and surface area affect the rate of body heat storage. The purpose of this investigation was to provide a data base to be used when interpreting M/SA data in the future. The effects of gender, ethnic group, and age on the distribution of M/SA were examined, in addition to the relationship between M/SA and other physical characteristics. This report also describes the physical characteristics of individuals at the extremes of M/SA distribution, who may have reduced heat dissipation capacity under certain conditions of heat and humidity. Important findings may be

summarized as follows: (1) M/SA increased significantly in both males and females after age 24, and after age 29 in males ($p < .025$). Therefore M/SA should be compared with data in the appropriate age group. The increase in M/SA with age may be explained by an increase in percent body fat (%BF). %BF increased significantly in both males and females after age 24 ($p < .025$). (2) M/SA was statistically similar between ethnic groups in males and females. However, black males had a lower %BF and a larger fat-free mass than males in other ethnic groups ($p < .001$). (3) For the first time, four equations are presented which allow an accurate calculation of M/SA ($r^2 = .99$) using only height and weight. The results of this investigation will be useful in analyzing data in future studies designed to determine if M/SA is in fact an index of heat tolerance.

14. Jones, B.H., Manikowski, R., Harris, J., Dziados, J., Norton, S., Ewart, T. and Vogel, J.A. Incidence of and risk factors for injury and illness among male and female Army Basic Trainees. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T19/88, 1988.

To establish the incidence of and risk factors for training injuries and illness, 310 U.S. Army Trainees (124 men and 186 women) were followed prospectively through one basic combat training (BCT) cycle of eight-weeks' duration. During BCT 51% of females and 27% of males were injured. Females suffered 481 days of limited duty secondary to injury while males incurred 99 days of limited duty. For females slow-mile time, low number of push ups and sit ups, high and low body mass index, and short and tall stature were associated with increased risk and injury during BCT. For males slow-mile time, high body mass index and low levels of previous physical activity were associated with increased risk for injury. When risk of injury for females versus males was adjusted for physical fitness level there was no difference in risks between them. In regard to illness, 48% of females and 35% of males reported on sick call for an illness of some kind. However, if risks of illness were compared excluding gynecological complaints, the risks were 37% for females and 35% for males. Also 26% of females and 28% of males required medical

care for an upper respiratory tract infection (URI). The total number of days of limited duty due to illness for females was 23 and males 19, mostly secondary associated with increased risk of having an upper respiratory tract infection, while for males both slow-mile times and low levels of prior activity were associated with risk of an upper respiratory tract infection. Major conclusions drawn from this study of a population of male and female trainees were that injury was the major cause of morbidity and that higher risks for injury and to some extent illness were associated with low levels of initial fitness and low levels of prior physical activity.

15. Vogel, J.A., Kirkpatrick, J.W., Fitzgerald, P.I., Hodgdon, J.A. and Harman, E.A. Derivation of anthropometry based body fat equations for the Army's weight control program. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report 17/88, 1988.

Large inter-observer variability is a major disadvantage to the use of skinfold measurements for the prediction of percent body fat. This is particularly relevant in the Army's weight control program where standardized training is difficult for the large number of required observers located worldwide and who frequently turn over due to reassignment. This necessitated the development of an alternative method that required no formal training, could be administered by non-technical personnel and had low inter-observer variability. This report describes circumference-based equations that were developed to replace the skinfold equations. The equation selected for males was: % body fat = $46.892 - (68.678 \times \log_{10} \text{ height}) + (76.462 \times \text{Log}_{10} (\text{abdominal circumference} - \text{neck circumference}))$ with a R of 0.817 and a SEE of 4.020. The selected female equation was: % BF = $-35.601 - (0.515 \times \text{height}) + (0.173 \times \text{hip circumference}) - (1.574 \times \text{forearm circumference}) - (0.533 \times \text{neck circumference}) - (0.200 \times \text{wrist circumference}) + (105.328 \times \text{Log}_{10} \text{ weight})$ with a R of 0.82 and SEE of 3.598. Height and circumferences are expressed in centimeters and weight in kilograms. The equations apply to all ages and racial groups. Conversion tables were developed for easy calculation of percent body fat from the raw measurements of circumferences, height and weight. In those

individuals exceeding the weight-height table, the equation was more accurate in males in correctly classifying individuals than the weight-height table but only marginally better in women. Cross-validation of the equations with an independent sample of Navy personnel resulted in an R of .89, an SEM of 3.7 and a mean difference with densitometry of 3.2% body fat units for men and an R of .79, SEM of 4.4 and a mean difference with densitometry of 0.2% body fat units for women. In addition to the ease of measurement by non-technical observers, the equations better predict % body fat measured by hydrostatic weighing than the previously used Durnin-Womersley skinfold equations when considering all ages, racial groups and degrees of adiposity.

16. Rose, M.S., Szlyk, P.C., Francesconi, R.P., Lester, L.S., Armstrong, L., Matthew, M., Cardello, A.V., Popper, R.D., Sils, I., Thomas, G., Schilling, D. and Whang, R. Effectiveness and acceptability of nutrient solutions in enhancing fluid intake in the heat. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T10/89, 1989.

Two colored, flavored, 2.5% carbohydrate-electrolyte solutions (Armyade and NBC Nutrient solution) with varying levels of magnesium, potassium and phosphorus were tested for ad libitum consumption and acceptability during eight days of work in a hot environment (max $T_{amb} = 31-38^{\circ}\text{C}$). Sixty-one male and female soldiers were divided into four test groups. A Control group drank water while the remaining three groups were given one of the following test beverages: NBC Nutrient solution, Armyade, or a colored flavored water (placebo). All four groups were allowed to consume other fluids such as plain water, soda, juice, etc. Acceptability in terms of hedonic ratings and consumption rate was determined. Two subjects absolutely refused to drink the assigned test beverage (Armyade and Placebo) after the first day, but did rate their acceptability at the end of the study. The data on the acceptability of the test beverages and demographics were assigned to the appropriate groups for these two subjects, however, the biochemical, hydrational, food and fluid consumption data were analyzed as if these two subjects belonged to the Control group. There were no group differences in terms of energy intake. The

subjects in the NBC group had a significantly higher ($p<0.001$) average daily fluid intake than those in the Armyade group, but their intake was not significantly greater than that of the soldiers in the Control (water) or Placebo groups. Under conditions of light-moderate activity, moderate heat stress, and when other colored-flavored beverages are available, there is no evidence that carbohydrate-electrolyte beverages will enhance fluid consumption over plain water. However, partitioning the total fluid intake for each subject into Colored Flavored Test Beverage (CFTB), water, and other fluids for the Armyade, Placebo and NBC (not Control group since the test beverage had been plain water) groups, indicated that consumption of the CFTB was significantly greater ($p<0.001$) than water and other fluid consumption, with subjects in the Placebo group drinking up to ten times as much CFTB as water.

17. Rose, R.W., Morgan, T.E., Rose, M.S., Srinivasan, S.R., Berenson, G.S. and Askew, E.W. Population screening for blood lipid levels and related coronary heart disease risk factors among U.S. Army Basic Trainees. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T2/89, 1988.

The purpose of this study was to determine the incidence of coronary heart disease (CHD) risk factors found among U.S. Army Basic Trainees. Total serum cholesterol levels, medical histories, tobacco use, and dietary intakes were determined for 258 male and female Basic Trainees during their first three weeks of Basic Training (dietary intakes are discussed in a separate technical report). Triglyceride, HDL-cholesterol, and LDL-cholesterol levels also were determined for 79 of the 258 participants. Blood lipids were determined by two different methods to test the agreement between different methods. The mean total serum cholesterol level for males (mean age 19) was 140 ± 25 mg/dl (Mean \pm SD) and for females (mean age 20) 162 ± 28 mg/dl. Although these serum cholesterol levels appear low, they may be somewhat misleading due to an "adolescent drop" in serum cholesterol levels often found in 16-20 year olds. Serum cholesterol levels between 200-239 mg/dl were found in 3 of the 125 males (3%) and 11 of the 126 females (9%). Serum cholesterol levels above

239 mg/dl were not observed. Serum cholesterol levels could not be determined for seven trainees. A family history of high blood pressure was the most frequently identified CHD risk factor obtained from the Basic Trainees' medical histories (54% of the males and 55% of the females). The incidence of family history of premature CHD, high cholesterol, stroke and diabetes were identified by 14-26% of the males and 16-28% of the females depending upon the risk factor. Trainees were prohibited from smoking during basic training; however, prior cigarette smoking was reported by 43% of the males and 37% of the females. Of the basic trainees who quit smoking cigarettes just prior to basic training, 40% of the males said that they would resume smoking cigarettes after completion of basic training. Only 18% of the females said that they definitely would resume smoking; 58% were undecided. Blood lipid profiles were determined for 40 males and 39 females. Males had a mean total cholesterol (TC) level of 149 ± 29 mg/dl (mean \pm SD), mean LDL cholesterol (LDL-C) levels of 92 ± 27 mg/dl, and mean HDL cholesterol (HDL-C) levels of 51 ± 12 mg/dl. Females had mean TC levels of 165 ± 26 mg/dl, mean LDL-C levels of 98 ± 25 mg/dl, and HDL-C levels of 59 ± 14 mg/dl. The mean TC/HDL-C and LDL-C/HDL-C ratios were 3.05 and 1.93 for males and 2.87 and 1.73 for females. The results of this study along with findings taken from other military studies indicate that intervention programs to lower CHD risk factors should start early in a soldier's career.

18. Rose, R.W., Baker, C.J., Salter, C., Wisnaskas, W., Edwards, J.S.A. and Rose, M.S. Dietary assessment of U.S. Army Basic Trainees at Fort Jackson, SC. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T6/89, 1989.

The dietary intakes of 41 male and 40 female basic trainees were collected and analyzed for seven days during August 1988. This information was used to determine the overall nutritional adequacy of diets; the number of soldiers consuming excessive amounts of fat, cholesterol and sodium, and the major foods contributing to excessive intakes. These nutrients were targeted because of their association with the development of coronary heart disease. Additional information was collected from a larger sample of soldiers (128

males, 130 females), which included the 81 soldiers from which dietary intakes were collected. Additional data were collected to support the Army Health Risk Appraisal Program and to provide Army planners with information needed to make decisions concerning future nutrition education programs and other nutrition initiatives. The information included: blood lipid levels; food consumption habits prior to basic training, and the levels of nutrition knowledge, attitudes, and awareness possessed by soldiers who were just starting their Army careers. These basic trainees were consuming diets which met or exceeded the Military Recommended Dietary Allowances (MRDA) for energy, protein, vitamins and minerals. However individually, many females did not meet the MRDA for calcium (47%), Vitamin B₁₂ (30%) and iron (50%). Many of these inadequate intakes (i.e., nutrient intakes below the MRDA) were the result of low consumption of dairy products, eggs, and other animal products. These inadequate intakes were especially noted for females consuming total fat intakes between 25-29% of calories as fat.

19. Rose, M.S. Between-meal food intake for reservists training in the field. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T15/89, 1989.

Soldiers take non-ration food items to the field to supplement the A-ration and Meals, Ready-to-Eat (MRE) foods that are served. The adequacy of data analyses of nutrient intakes in the field depends on whether the foods eaten between meals are included in the analyses. During eight days of work in the field in a hot environment by a reserve field medical unit, the intake of between-meal foods and fluids accounted for 25% of the total energy intake. About 27% of the between meal foods and fluids were beverages. The soldiers skipped 13% of the A-ration meals with a majority (55.5%) skipping breakfast. MRE consumption for the reservists at the lunch meal in this study (44%) was much lower than the 70-80% reported previously for active duty soldiers when consumption of non-ration between meal foods was strongly discouraged.

20. Fine, B.J. Effects of mild-to-moderate ambient cold and chemical protective clothing (MOPP-IV) on cognitive performance of male and female soldiers: an addendum to Technical Reports T11/85 and T7/88. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T19/90, 1990.

Previous reports from this Institute describe two studies in which ambient heat (32.8°C, 61% rh) was found to affect the mental performance of male and female soldiers wearing chemical protective clothing (MOPP-IV). In the first study (T7-88), female soldiers, under identical conditions, showed impairment within three hours and fewer were able to sustain performance for the entire seven-hour exposure. A "MOPP-Control" condition was included in both studies to assess performance MOPP-IV without heat stress. The ambient temperature for this condition (12.8°C) was determined by calculating its thermal comfort equivalence with another control condition in which only the Battle Dress Uniform (BDU) was worn (21.1°C). The matching of the two conditions for thermal comfort enables differences between them to be attributable to aspects of the MOPP system other than its insulation. Large decrements in performance, not easily accounted for by any aspects of the MOPP system, were found for both males and females when in the MOPP-Control condition. To further understand these decrements, data from both studies have been reviewed. It was discovered that a metabolic rate for active (150 watts) rather than inactive (100 watts) personnel was used in determining the appropriate temperature for MOPP-Control condition. Revised calculations, which assume metabolic rates of 100 watts for men and 85 watts for women, estimate ambient temperatures of 16.3°C and 19.2°C for males and females respectively, as the appropriate MOPP-Control subjective comfort matches for the BDU-Control condition. The new information suggests that, in both studies, personnel were exposed to a mild to moderate cold stress while in the MOPP-Control condition. This may account for a significant portion of the decrements in performance noted. The results suggest potentially serious operational problems for mental performance in MOPP-IV in mild to moderately cold environments as well as in the heat.

21. Friedl, K.E., Vogel, J.A., Bovee, M.W. and Jones, B.H. Assessments of body weight standards in male and female Army recruits. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T15/90, 1989.

Army enlisted candidates are screened for obesity with height-weight tables (AR 40-501) which exclude few young males but approximately one third of young females in the U.S. population. Another regulation (AR 600-9) sets standards for retention in the Army on the basis of body fat estimated from circumferences. The effects of these two disparate sets of standards were studied in a sample of 1894 recruits starting basic training at Fort Jackson in Fall 1988, concluding with a survey conducted through their company commanders, six months after basic training. The suitability of accession weight standards with respect to the retention standards was examined by studying the effect of excess fatness on attrition from active duty, physical performance and ability to achieve fat standards after basic training. The data suggest that accession standards should be based on body fat; the gap between the two male standards should be reduced; further study is necessary to determine if females could be granted a similar allowance, and female body fat (retention) standards should be liberalized.

22. Friedl, K.E., Marchitelli, L.J., Sherman, D.E. and Tully, R. Nutritional assessment of cadets at the U.S. Military Academy: Part 1. Anthropometric and biochemical measures. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T4-91, 1990.

A study of 128 male and 90 female cadet volunteers at the U.S. Military Academy was conducted in April 1990 to assess nutritional health end points of body composition, serum lipids, and iron status, as part of a larger nutrition study. The body composition of cadets has not changed from that measured in cadets ten years ago. Mean values of circumferentially-determined body fat were 12% (men) and 26.5% (women); no men and only 14% of the women were overfat by AR 600-9 standards for 21-27 year olds, although by the standards of the Cadet Weight Management Program, half of the women would

be classified as overfat. In this fit sample of cadets, 80% of women and 37% of men stated that they were attempting to lose weight. Serum lipid profiles indicated low cardiovascular disease risk for this population; 6% of men and 3% of women in this study exceeded the cholesterol and LDL-cholesterol screening limits recommended by the National Cholesterol Education Program. When all cadets in this population were considered, skinfold-determined fatness, fasting serum insulin levels, and family history of high blood pressure were factors most related to higher levels of cholesterol and/or decreased HDL-cholesterol for the males, but fatness was unrelated for the women. All measures of iron status indicated a greater risk of iron deficiency anemia in comparison to the 1979 study of cadets, a direct result of a blood drive which occurred in the week prior to our study; one third of the women who had given blood were classified with iron deficiency anemia, suggesting that prior to blood donation a more intensive screening procedure should be applied to female cadets. Comparisons of mean values indicated that the use of iron supplements by the women was beneficial to various hematological parameters, including those women who gave blood. We recommend that women should not be held to a body fat standard which is more stringent than the current Army standard described in AR 600-9. At the other extreme, excess fat intakes should be discouraged through appropriate dietary education and, most importantly, through the example established by the Cadet Mess with the observance of Army-wide goals of fat content at less than 30% of total calories.

23. Hodgdon, J.A., Fitzgerald, P.I. and Vogel, J.A. Relationships between body fat and appearance ratings of U.S. Soldiers. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T12/90, 1990.

Military Service requirements to maintain physical appearance is a portion of the driving force for the Service Standards regarding the maximum weight for height and body composition. This report considers two issues: 1) how strongly are ratings of "military appearance" and fatness associated, and 2) can reliable, valid assessments be made visually in a military population which includes both genders and contains members of varying race and age. A panel of 11 U.S. Army personnel made visual ratings of 1075 male and 251 female

subjects from photographs both in uniform and in swimsuit. Subjects were rated for "appearance" in both uniform and swimsuit using a 5-point scale, and for "fatness" in swimsuit using a 7-point scale developed by Blanchard and co-workers. Inter-rater reliabilities of the scales were 0.86, 0.90, and 0.92 for appearance in uniform, appearance in swimsuit, and fatness in swimsuit, respectively. Correlations between ratings and percent fat from hydrodensitometry for males in this sample were 0.53, 0.69 and 0.78 for appearance in uniform, appearance in swimsuit, and fatness, respectively. Similar correlations for females were 0.46, 0.60 and 0.72. Analysis of variance using percent body fat as a covariate revealed significant gender and race main effects and a gender by age interaction in ratings of appearance in uniform; gender and age by gender effects in ratings of appearance in swimsuit; and a gender effect in ratings of fatness. For a given percent body fat value, a woman received a higher rating of military appearance, and a black soldier received a higher rating of military appearance. The gender by age interaction appears to reflect an increased sensitivity in rating older females than younger females or males of either age group. Validities for prediction of percent body fat from ratings of fatness approach those for prediction from anthropometric variables. Ratings of appearance appear to involve more than a consideration of the fatness of the individual. Thus a single rating scale for appearance and fatness is not feasible. Visual ratings of fatness appear to be valid, reliable indicators of percent body fat.

24. Edwards, J.S.A., Askew, E.W., King, N., Fulco, C.S., Hoyt, R.W. and Delany, J.P. An assessment of the nutritional intake and energy expenditure of unacclimatized U.S. Army soldiers living and working at high altitude. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T10/91, 1991.

During a recent deployment to Bolivia (3500-4050 m elevation), 36 male soldiers (control) ate the field rations (B/MRE/B). Another 32 male soldiers ate the field rations plus CHO supplement, and 13 female soldiers ate the field rations plus a high CHO (125 g) food supplement. Daily urine samples were

obtained. Body weights, food/fluid intakes, and food acceptability were recorded for 15 days. A sub-sample of 30 soldiers provided 24-hour urine sample for the first and last two days of the study. Energy expenditure was measured on a sub-sample (n=12) using doubly labelled water. Caloric intake decreased for the first three days at altitude; picked-up on day four, and leveled out thereafter. Mean daily energy intakes were 2140 kcal for the male control group; 2265 kcal for the male supplemented group, and 1668 kcal for the female group. Caloric intakes for the male groups were not significantly different. Mean daily energy expenditure was 3549 kcal. Consequently, all groups lost body weight, 3.71 lbs, 3.78 lbs, and 1.16 lbs, respectively. Mean CHO intake was 46, 48 and 52% of the energy intake, respectively. Ration acceptability was good and did not decline over time. These results show that B Rations and the MRE are equally suited for use at altitude and sea level but also demonstrate that soldiers given an *ad libitum* dietary regimen and a food packet CHO supplement, did not automatically increase their CHO intake. It was concluded, therefore, that if an increase in CHO intake at altitude is desirable then a beverage component supplement may be more effective.

25. Rice, V.J., Pentikis, J.S., Rush, V., Murnyak, G. and Nindl, B. Ergonomic worksite analysis of an Army dental clinic. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T11/92, 1992.

The purposes of this worksite analysis were: (1) to identify the prevalence of cumulative trauma disorders (CTDs), associated symptoms and risk factors, with special attention to carpal tunnel syndrome (CTS), (2) to identify practitioners at risk, and (3) to offer suggestions for early identification and prevention of injuries. The worksite analysis of the Fort Leonard Wood, DENTAC, involved videotaping, photographing work stations, administering two questionnaires, reviewing medical records, and interviewing selected personnel. One or more symptoms indicative of CTS were noted by 75.6% of the dental workers and 11% reported diagnosed CTS. Although dental assistants expanded functions (DAEFs) were found to be at greatest risk for development of upper extremity symptoms and carpal tunnel syndrome, each of the MOS

groupings displayed a high percentage of hand/wrist symptoms. Back and shoulder pain was reported by 53% of the respondents. Psychosocial factors as well as physical risk factors were found to be associated with cumulative disorder symptoms. Suggestions for injury surveillance and prevention were offered.

26. Jones, T.E., Mutter, S.H., Aylward, J.M., DeLany, J.P., Stephens, R.L., Caretti, D.M., Jezior, D.A., Cheema, B., Lester, L.S. and Askew, E.W. Nutrition and hydration status of aircrew members consuming the Food Packet, Survival, General Purpose, Improved during a simulated survival scenario. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T1/93, 1992.

Adequate nutrition and hydration can be crucial to the survival of downed aircrews. To determine the nutritional adequacy and palatability of an improved, all-purpose, all-environment survival packet (GP-1) compared to the old survival packet (GP), a field test was conducted using combat survival school students. During a five-day survival exercise, 41 aircrew members ate the GP-1 and 57 ate the GP. Nutrition/hydration status was assessed from food/fluid intake records as well as changes in body weight. Water turnover was measured in a subset of subjects ($n=30$) using deuterium oxide. Pre- and post-test hemoglobin, hematocrit, plasma osmolality, urine specific gravity (SG) and ketones were also measured. Acceptability of the two rations was evaluated. Subjects eating the GP-1 consumed more calories; GP-1 774 ± 436 vs GP 642 ± 408 kcal/d. Carbohydrate and protein consumption were similar but the GP-1 group ate significantly more fat, 35 ± 21 vs 24 ± 18 g/d. Mean fluid intake was similar for both groups (GP-1 4.3 ± 1.7 , GP 4.4 ± 1.9 L/d. Sodium intakes were 1.6 g/d. Weight decreased significantly for the GP-1 and GP groups (2.9 ± 1.4 , 3.4 ± 1.7 kg, respectively); changes were similar between groups. Water turnover data indicated subjects maintained adequate hydration as did hemoglobin, hematocrit, and plasma osmolality. Mean post-test urine SG was 1.024 ± 0.007 and moderate amounts of ketones were detected. Both rations received favorable ratings, but the greater variety of the GP-1 ration resulted in higher acceptability ratings. We conclude from these results that

either ration is adequate, however, the variety and palatability of the GP-1 is more desirable than the GP.

27. Rose, M.S., Moore, R., Mahnke, R., Christensen, E. and Askew, E.W. Weight reduction techniques adopted when weight standards are enforced. Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T4/93, 1993.

This study examined the prevalence of weight problems in the Army and examined the techniques that soldiers used to lose weight when weight standards were enforced. Analysis of 1069 questionnaires from US Army soldiers showed that only 2.8% of the soldiers had participated within the last year in the Army Weight Control Program (AWCP). However, 57.8% of all the soldiers had attempted to lose weight at some time in their life; 16.7% were overweight according to the Army's Maximum Allowable Weight standards, and 85.9% considered themselves to be overweight according to their personal ideal weight. About 13.6% had attempted to lose weight before 18 years of age, which indicates long-term weight problems; 65.9% of all soldiers had gained weight since joining the Army. The weight change was an 8.7 ± 19.3 lb (mean \pm SD) weight gain. Weight concerns appear to be a lifetime problem starting long before some soldiers join the Army; affecting more soldiers than those identified by the AWCP, and possibly developing during a career in the Army. Nutrition/education programs should begin during Basic Training and continue annually to catch those who have been attempting to lose weight since childhood and to prevent the weight gain that appears to be inevitable with aging and a career in the Army.

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